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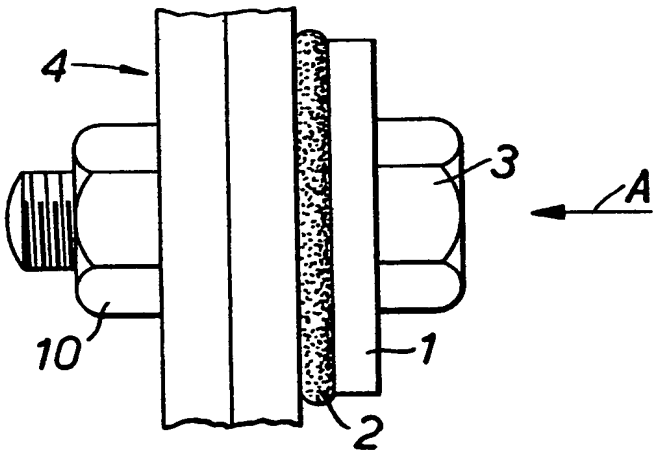
(54) **Load-indicating washer**

(57) A composite load-indicating washer (1, 2) is provided for visually indicating when a nut and bolt combination (3, 10) has been tightened to a predetermined degree. In its simplest form, the composite washer comprises a relatively rigid annular element (1), such as a steel washer, arranged in coaxial face-to-face relation with a relatively deformable element (2), for example, of soft nylon or neoprene. In use, the composite washer (1, 2) is located on the shank of a bolt (3) between the workpiece (4) concerned and either the bolt head or a mating nut (10). As the nut and bolt combination (3, 10) is tightened, the deformable element (2) expands radially until at a preset tightness, its diameter exceeds that of the rigid element (1) acting as a reference; the deformable element (2) is now visible around the edge of the rigid element (1) indicating that the required tightness has been achieved.

FIG.3.



GB 2 120 795 A

FIG.1.

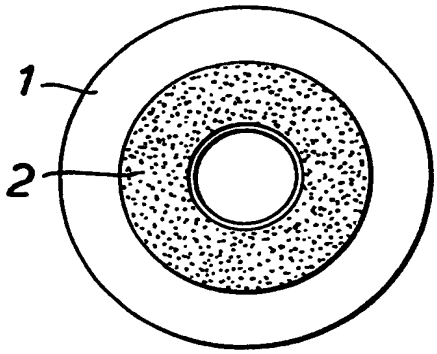


FIG.2.

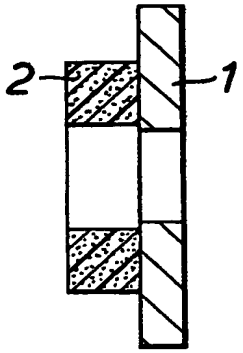


FIG.3.

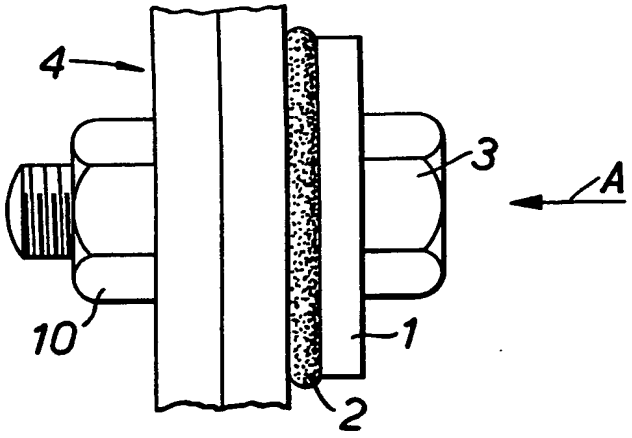


FIG.4.

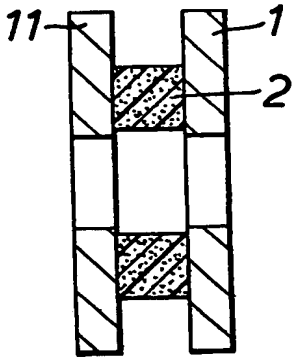


FIG.5.

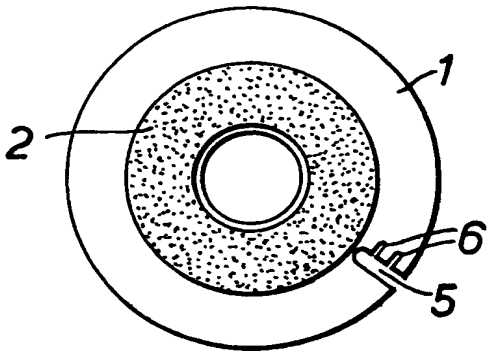


FIG.6.

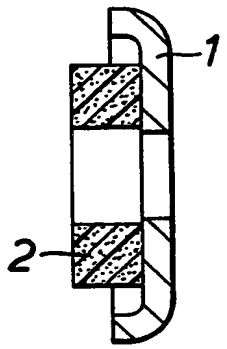


FIG.7.

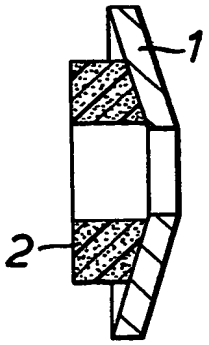


FIG.8.

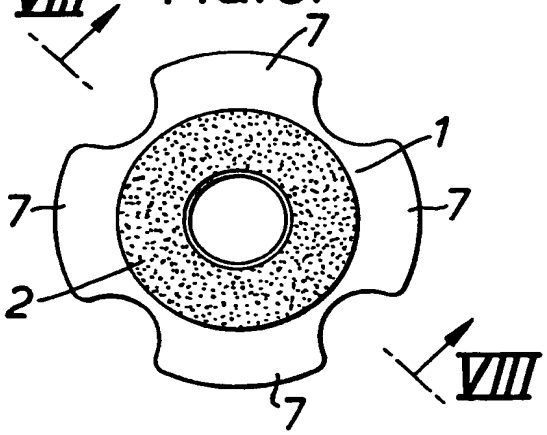


FIG.9.

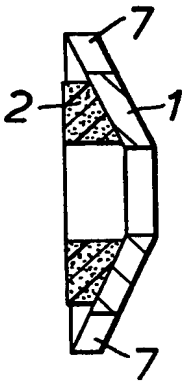
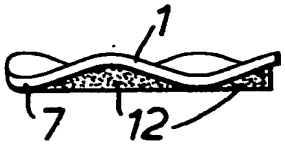


FIG.10.



SPECIFICATION

Load-indicating washer

The present invention relates to a load-indicating washer for visually indicating when a nut and bolt combination has been tightened to a predetermined degree.

It is well appreciated that the under or over-tightening of nut and bolt combinations can prove prejudicial to the safety of the apparatus or structure in which they are incorporated. As a result, various techniques have been employed in the past to provide a check on the tightening of nut and bolt combinations; however, none of these techniques has proved wholly satisfactory in practice, either due to their cost or inconvenience in use. With respect to this latter factor, experience has shown that any checking technique requiring other than minimal involvement of a labour force will generally fail to be consistently used except when the labour force is constantly encouraged to do so. A further disadvantage of certain prior art checking techniques is that they provide only a transient indication that a nut and bolt combination has been tightened to a predetermined degree.

One recent proposal for providing a visual check on the tightening of a nut and bolt combination involves the use of a standard rubber O-ring seated in an annular groove machined in the workpiece-facing surface of the head of a bolt. In addition to this groove, the head of the bolt is also formed with a small hole extending through the head from the groove in a direction parallel to the bolt's axis to open out into the outer end surface of the bolt's head. In use, a steel washer is interposed between the head of the bolt and the workpiece to trap the O-ring in its groove. As the bolt is tightened, the O-ring is placed under load and flows into the only free space available, that is, the hole formed in the head. The appearance of a small pip of rubber on the outer end surface of the bolt's head indicates that the bolt has been tightened to the desired degree.

While this prior art arrangement provides a semi-permanent visual indication of the bolt's tightness and is convenient to use, it does suffer from several disadvatanges such as the need to accurately machine a groove and through-hole into the head of the bolt. Furthermore, the accuracy of the technique depends on the quality of seal provided by the washer.

It is an object of the present invention to provide a way of checking the tightening of nut and bolt combinations which is not only quick and easy to implement and gives a permanent or semi-permanent record of the degree of tightening, but is also cheap and simple and does not require accurate machining of the nut and bolt combination.

According to one aspect of the present invention, there is provided a composite load-indicating washer for visually indicating when a nut and bolt combination has been tightened to a predetermined degree, said washer comprising a relatively rigid, annular element arranged in coaxial, face to face, relation with a relatively deformable annular element of smaller diameter, the deformable element being arranged to expand radially outwards across the juxtaposed annular face of the rigid element upon compression of the washer, and the rigid element serving to provide a reference relative to which the radial expansion of the deformable element, and thus the compression of the washer, can be visually judged.

Preferably, the rigid annular element is a steel washer and the deformable element is made of a material such as soft nylon or neoprene rubber. In use of the load-indicating washer, the washer is interposed between the workpiece concerned and either the nut or the head of a bolt of a nut and bolt combination to be tightened, the rigid annular element being away from the workpiece. As the nut and bolt combination is tightened, the deformable element of the washer expands radially until at a given tightness, corresponding to said predetermined degree, its diameter exceeds that of the rigid washer element serving as a reference; the deformable element is now visible around the edge of the rigid element when the nut and bolt combination is viewed end on, indicating that the combination has been tightened to the desired degree.

Advantageously, the deformable element is made brightly coloured to facilitate rapid visual inspection of a number of bolts.

The two elements of the load-indicating washer may be bonded together or may be separately engaged with the shank of a bolt.

By using rigid annular elements of different diameters, different degrees of tightening can be judged. Furthermore, a graded reference can be provided, for example by forming a radial recess in the periphery of the rigid element so that the progress of the expansion of the deformable element is made visible, the recess being graduated either by steps in its sides or by adjacent markings; alternatively, in certain applications, a transparent rigid element could be used to permit visual monitoring of the progressive expansion of the deformable element.

It is, in fact, possible to divide the load-indicating washers of the invention into two different types. In one type, the forces transmitted through the washer from the nut or bolt head to the workpiece concerned, pass first through the relatively rigid washer element and then through the relatively-deformable washer element, so that this latter element is subjected to the full loading of the nut and bolt combination and is deformed accordingly. In the second type of washer, the relatively rigid element is formed with axially-extending portions which serve to provide a path, in parallel with that provided by the relatively-deformable element, for the forces passing between the rigid element and the workpiece. The form and material composition of the relatively-rigid element is such that not only will the majority of the forces transmitted by the washer pass through the said axially extending portions rather than through the relatively - deformable element, but the relatively - rigid element will also by subject to significant axial compression by an

amount dependent on the loading of the washer, so that the relatively-deformable element will be effectively axially deformed in proportion to the loading of the washer. This second type of washer is advantageous in applications where there is a risk of deterioration with time of the relatively-deformable element, since the tightness of the nut and bolt combination will be virtually unaffected by the disappearance of this latter element, the stress path through the washer being provided by the relatively-rigid element.

The load-indicating washer can incorporate a second rigid annular element (again, for example a steel washer) provided on the opposite side of the deformable element to the first-mentioned rigid annular element, the deformable element being then sandwiched between the two rigid elements. Such an arrangement ensures that the radial expansion of the deformable element is independent of the surface roughness of the workpiece.

Various other novel aspects and features of the invention will become apparent from the following description, given by way of example, of several forms of load-indicating washer, reference being made to the accompanying diagrammatic drawings, in which:

Figure 1 is a plan view of a first form of washer embodying the invention;

Figure 2 is a cross-section through the Figure 1 washer;

Figure 3 is a side view of the Figure 1 washer in use in conjuction with a nut and bolt combination;

Figure 4 is a cross-section similar to Figure 2, through a first variant of the Figure 1 washer;

Figure 5 is a plan view of a second variant of the Figure 1 washer;

Figures 6 and 7 are sections similar to Figure 2 respectively showing second and third forms of washer embodying the invention;

Figure 8 is a plan view of a fourth form of washer embodying the invention;

Figure 9 is a section on line VIII-VIII of Figure 8, and

Figure 10 is a side elevation of a fifth form of washer embodying the invention.

As shown in Figures 1 and 2, the first form of load-indicating washer comprisies a relatively-rigid annular element in the form of a flat steel washer element 1, and a relatively - deformable annular element 2 formed of soft nylon or neoprene rubber. The deformable element 2 is of a substantially smaller diameter than the steel washer element 1 and is bonded to one face of the latter by any suitable means. The element 2 is brightly coloured.

In use, the load-indicating washer is interposed between a workpiece 4 (see Figure 3) and either the head of a bolt 3 or a nut 10 of a nut and bolt combination being used in conjuction with the workpiece; in Figure 3, the washer is shown interposed between the workpiece 4 and the head of the bolt 3, the steel washer element 1 being towards the bolt's head. As the bolt 3 is tightened, the load-indicating washer is compressed with the result that the relatively - deformable element 2 is squeezed radially outwards. At some point, the diameter of the element 2 will exceed that of the element 1 so that the brightly coloured element 2 becomes visible when the bolt is viewed in the direction indicated by arrow A in Figure 3. The dimensioning of the elements 1 and 2 is chosen such that the element 2 becomes visible around the periphery of the element 1 when the required degree of tightness of the bolt 3 has been achieved.

It will be appreciated that in the form of washer illustrated in Figures 1 to 3, the relatively - deformable element 2 is subject to the full loading experienced by the bolt 3 since there is no other path for the transmission of forces between the workpiece 4 and the head of the bolt 3.

Figure 4 shows a varient of the washer illustrated in Figures 1 to 3, in which a second flat steel washer element 11 is provided, the deformable element 2 being disposed between the two steel washer elements 1, 11. Such an arrangement ensures that the radial expansion of the deformable element 2 upon compression of the washer, is independent of the surface roughness of the workpiece concerned.

The variant of the Figure 1 washer shown in Figure 5, is formed with a recess 5 provided with notched graduations 6 in one radially - extending wall thereof. The provision of the recess 5 enables a progressive visual check to be made on the radial expansion of the relatively - deformable element during tightening of a nut and bolt combination. The graduations 6 serve to provide an indication of when different degrees of tighening of the nut and bolt combination have been achieved.

Figures 6 and 7 show, in cross-section, two further forms of load-indicating washer operating on the same principle as the Figure 1 washer. Various other shapes of washer are, of course, possible.

The form of load-indicating washer shown in Figures 8 and 9 differs from those shown in Figures 1 to 6 in that it is provided with axially extending portions 7 which are arranged to project around the relatively-deformable element 2 to provide, in parallel with this latter element, a path for forces passing between the body of the relatively-rigid element 1 and a workpiece. The form and material composition of the relatively-rigid element 1 is chosen such that not only will the majority of forces transmitted by the washer pass through the portions 7 rather than through the relatively-deformable element 2, but the relatively-rigid element 1 will also be subject to significant axial compression as the associated nut and bolt combination is tightened. As a result, the relatively-deformable element 2 of the washer will be effectively axially compressed, and thus radially expanded, in proportion to the loading of the washer. This arrangement is advantageous in applications where the element 2 may deteriorate with time since the disappearance of this element will not substantially affect the bolt tightness, the stress path through the washer being at all times provided almost exclusively by the relatively - rigid element 1.

The form of the axially-extending portions 7 may, of course, be varied from that illustrated in Figures 8 and 9. Thus, in the form of load-indicating washer shown in Figure 10, the element 1 is of circular, wavy form and the element 2 is of complementary shape, the troughs in the latter element being filled by the portions 7 of the element 1. As can be seen in Figure

10, the main mass of the element 2 is divided into sections 12 bounded by adjacent portions 7 of the element 1; these sections 12 can be interconnected into a single body either by thin webs extending circumferentially beneath the portions 7 or by a radially-inner annular ring (not visible) arranged to lie in a complementary seat formed in the element 1.

Any of the washers illustrated in Figures 5 to 10 can, of course, be provided with a second flat rigid element 11 in the manner illustrated in Figure 4 for the washer of Figures 1 to 3.

CLAIMS (Filed on 6 May, 83)

1. A composite load-indicating washer for visually indicating when a nut and bolt combination has been tightened to a predetermined degree, said washer comprising a relatively-rigid, annular element arranged in coaxial, face to face, relation with a relatively-deformable element of lesser radial extent, the deformable element being arranged to expand radially outwards across the juxtaposed annular face of the rigid element upon compression of the washer, and the rigid element serving to provide a reference relative to which the radial expansion of the deformable element, and thus the compression of the washer, can be visually judged.

2. A load-indicating washer according to Claim 1, wherein the arrangement of the elements is such that, in use, forces passing through the washer are transmitted serially through said elements.

3. A load-indicating washer according to Claim 1, wherein the arrangement of the elements is such that, in use, forces passing through the washer are transmitted in parallel through the elements, the relatively rigid element transmitting the majority of said forces and being axially deformed thereby by an amount indicated by the radial expansion of the relatively deformable element.

4. A load-indicating washer according to Claim 3 wherein the relatively rigid element has an undulating circumferential form, the relatively deformable element being disposed on one side of the relatively rigid element in the hollows resulting from the undulating form of the latter.

5. A load-indicating washer according to any one of the preceding claims, wherein the deformable element is made of soft nylon or neoprene rubber.

6. A load-indicating washer according to any one of the preceding claims, wherein the rigid element is provided with a radial recess in its periphery so that the progress of the expansion of the deformable element can be seen.

7. A load-indicating washer according to any one of Claims 1 to 4, wherein the rigid element is made of a transparent material to permit visual monitoring of the progressive expansion of the deformable element.

8. A load-indicating washer according to any one of the preceding claims including a second relatively rigid annular element provided on the opposite side of the relatively deformable element to the first-mentioned relatively rigid element.

9. A load-indicating washer according to any one of the preceding claims, wherein the elements of the washer are bonded together.

10. A composite load-indicating washer, substantially as hereinbefore described with reference to any one of Figures 1, 4, 5, 6, 7, 8 and 10 of the accompanying drawings.

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